Manchester Geological Association
Williamson Building, University of Manchester
Saturday 15th November 2014 at 1.30pm

The Zechstein Sea and its Deposits

13.30 – 14.15 Upper Permian (Zechstein) Carbonates and Evaporites in NW Europe
Professor Maurice Tucker, University of Bristol

14.15 – 15.00 Palaeoceanographic Conditions and Organic Matter Preservation in the Southern and Northern Permian Basins during Upper Permian (Zechstein 2) Carbonate Deposition
Dr Miroslaw Slowakiewicz, University of Bristol

15.00 – 15.30 Coffee Break

15.30 – 16.15 The Evolution of an Upper Permian Evaporite Basin in Northwest England
Dr Noel Worley, Yorkshire Geological Society

Upper Permian (Zechstein) Carbonates and Evaporites in NW Europe
Professor Maurice Tucker, University of Bristol

Upper Permian (Zechstein) carbonates and evaporites were deposited from eastern England across the North Sea to Germany and Poland in an inland sea, like the present-day Mediterranean, with a connection to the open ocean through a narrow passage between Greenland and Scandinavia. Limestones and dolomites were deposited during sea-level highstands around the basin margins in reefal, shallow-shelf, lagoonal and tidal-flat environments similar to those today in the Bahamas and Trucial Coast (UAE). The Zechstein carbonates are well exposed along the coast of Co. Durham, with outcrops continuing southwards through Yorkshire to Nottinghamshire. The evaporites on the other hand were deposited at times of sea-level drawdown and lowstand, in the form of marginal gypsum wedges and basin-filling halite. These deposits have been dissolved out at outcrop and are represented by evaporite residues and spectacular collapse breccias. This talk will review the depositional history of the Zechstein facies and illustrate the variety of rocks seen at outcrop in England. Zechstein carbonates are a major type of hydrocarbon reservoir in the North Sea and Poland, and there is currently much exploration for further reserves of oil and gas, including in Yorkshire.

Palaeoceanographic Conditions and Organic Matter Preservation in the Southern and Northern Permian Basins during Upper Permian (Zechstein 2) Carbonate Deposition
Dr Miroslaw Slowakiewicz, University of Bristol

Evidence for photic zone euxinia (PZE) in Paleozoic oceans is widespread and commonly associated with global climate change and biotic events, for example, in association with Upper Permian and Lower Triassic strata. However, this evidence is largely restricted to marginal marine depositional settings, making it difficult to infer whether it is associated with widespread basin-scale anoxia. To explore the relationship between euxinia in marginal settings and the wider basin, a detailed spatial and temporal examination of the paleowater-column redox state from the Polish, German and English sectors of the Southern (SPB) and

Northern (NPB) Permian basins during deposition of the Zechstein (Lopingian) second carbonate (Main Dolomite) cycle. Sediments from basin rise, toe-of-slope, slope and hypersaline lagoonal settings of the northeastern margin of the SPB in Poland contain abundant chlorobactane, isorenieratane and their likely degradation products (C_{15} to C_{31} 2,3,6-aryl isoprenoids). These indicate that part of the photic zone was euxinic during significant intervals of the Main Dolomite deposition. Further evidence for strongly anoxic conditions includes the occurrence of C_{28}-bisnorhopane, high concentrations of pentakishomohopanes (i.e. high homohopane indices), and the occurrence of framboidal micropyrite and native sulphur crystals in slope facies in Poland and Germany. However, a lack of these signatures in basinal settings in the other parts of the SPB and in the NPB indicates that strongly reducing conditions were restricted to the slope, toe-of-slope and basin-rise locations in the eastern and central SPB. The NPB was most likely oxic. This indicates that a pronounced oxygen minimum zone (OMZ) instead of stratification appears to have sustained euxinic conditions in the photic zone for prolonged periods of time in the eastern SPB. Even in these settings, however, highly variable homohopane indices and concentrations of isorenieratene and chlorobactene derivatives, as well as the presence of benthic fauna and bioturbation, indicate that anoxia fluctuated throughout deposition of the Main Dolomite and its equivalents, likely on a variety of timescales. Sterane distributions are also variable, suggesting a dynamic ecosystem, likely exhibiting a strong response to environmental forcing. Overall, it appears that high but episodic primary bioproductivity of organic matter was concentrated on the basin-rise, slope and restricted lagoons leading to the formation of source rocks for petroleum; however, the temporal and geographical restriction of anoxia appears to have prevented the accumulation of large or more widespread quantities of organic matter and in fact TOC contents exhibit poor correlation with ecological and anoxia indicators. This model indicates that strong evidence for PZE in shelf and slope facies need not be associated with widespread, basin-scale anoxia, with implications for organic matter burial, carbon cycling and biotic crises.

The Evolution of an Upper Permian Evaporite Basin in Northwest England
Dr Noel Worley, Yorkshire Geological Society

During the Upper Permian along the western length of northwest England a series of fault-bounded basins developed in response to Variscan extensional tectonics that collectively formed the Irish Sea– Solway Basin. Sedimentary sequences were deposited in continental and marine settings. The Eden Valley half-graben satellite basin formed alongside the western margin of the Lake District massif. Rapid subsidence during the Lower Permian (Rotliegendes equivalent) comprises a marginal sequence of flash flood alluvial fan and wadi conglomerates (brockrams) which pass laterally into aeolian dune facies of the Penrith Sandstone. As much as 1km of clastic sediments accumulated in the depocentre. Siliclastic deposition largely ended during the Upper Permian and 3 periods of evaporite deposition are recognised that have been correlated on sparse paleontological evidence with better known Zechstein counterparts in the northeast England. The representatives of the first A Bed evaporite cycle took place in a geographically restricted area within a fault-controlled subsiding shallow basin. Evaporite deposition occurred by initial filling of localised sags and irregularities with relatively thick cyclical sequences in shallow water. Gypsum accumulated in 10 to 30 cm beds alternating rhythmically with thin beds of shale reflecting decreasing levels of aridity. Bed thickness progressively diminishes up the sequence and is characterised by gypsum – shale/siltstone couplets at millimetre scale deposited episodically, interpreted as a feature of a lacustrine environment. Halite accumulated towards the centre of the basin. The shales are grey coloured because of a high proportion of organic carbon phytoclasts of

terrestrial origin transported by fluvial action from a catchment area where a conifer dominated flora developed. These shales also preserve uncompressed three dimensional pyrite petrifactions that have a microbial flora. The preservation of gypsum primary structures is poor and the evidence suggests deposition occurred in shallow water and are frequently associated with algal stromatolites.

A further two periods of evaporite deposition took place – the B / C Bed and D Bed. Both are geographically more widespread and can be traced almost the full length of the Eden Valley and into the Carlisle Basin. The sequence of sediments overlaying the evaporites comprises mainly fluvial siltstones and sandstones of the Cumbrian Coast Group that are geographically more extensive reflecting more uniform subsidence conditions and filling of the basin. Subsidence continued throughout much of the Mesozoic and maximum burial occurred towards the end of the Cretaceous. During this time conversion of primary gypsum to anhydrite took place, a process that altered many of the original petrofabrics and was accompanied by thermal alteration of the organic material to vitrinite.

Regional thermal uplift during the Tertiary affected northern England and has continued to the present day removing as much as 2500 m of Mesozoic rocks. The present level of erosion has brought the evaporites to outcrop and has facilitated the re-conversion of anhydrite to gypsum by penetration of meteoric water. The rate of penetration is controlled by the permeability of the evaporites and full conversion rarely extends deeper than 25m; however the presence of the Penrith Sandstone beneath A Bed has uniquely caused hydration to take place to depths of over 250 m. The shales within the A Bed contain extensive secondary gypsum mineralisation that includes the daisy beds and satin spars. The latter form a series of flattened semi-ellipses and constitute as much as 30% of the rock by volume. This is interpreted as occurring by hydrofracturing of the weak shales by overpressured fluid within the underlying sandstone. Hydrofracturing was caused by a reduction of the vertical stress component when progressive removal of overburden commenced during the Tertiary inversion.